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(71) Applicant: Golberstein, Moshe
2100 Drew Avenue South
Minneapolis Minnesota 55416(US)

(72) Inventor: Golberstein, Moshe
2100 Drew Avenue South
Minneapolis Minnesota 55416(US)

(74) Representative: Powell, Stephen David et al
J.F. Williams & Co. 34 Tavistock Street
London WC2E 7PB(GB)

(54) **Reflective photometry instrument.**

(57) A relative reflective photometry instrument is provided for measuring surface reflectance of a specimen (17) and comprises a light source (1) at one end and a pair of photosensors (9, 23) at the other end, one of the photosensors (9) being positioned to receive rays directly from the light source and the other (23) being positioned to receive light scattered from the specimen. The photosensors are provided with a central opening (13) through which a portion of the light passes onto the specimen (17) and is thereafter reflected onto the photosensor (23). A comparing circuit (5, 79) can comprise a divider for establishing the ratio between the signals extracted from the two photosensors.

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REFLECTIVE PHOTOMETRY INSTRUMENT

Of the many instruments proposed for measuring surface reflectance optically, none are completely satisfactory with respect to cost, size, portability and accuracy. Most, if not all, prior instruments require an optical system that includes many lenses and other costly components such as half-silvered mirrors and special alignment schemes which increase cost, size, bulk, and reduce portability.

According to a first aspect of the present invention there is provided an instrument for measuring reflectance of a specimen characterised in that it comprises a light source, a first photosensitive surface in an optical relationship with the light source to receive impinging rays from said light source, a second photosensitive surface positioned relative to the light source and positionable with respect to a specimen to receive rays reflected from the specimen, supporting means to establish the distance between, a) the light source and the first photosensitive surface, b) the light source to the specimen, and c) the specimen to the second surface, circuit means connected to the photosensitive surfaces for comparing the signal from the first and second photosensitive surfaces and output means connected to the comparing means indicating means indicating the reflectance of the specimen, at least one of the photosensitive surfaces having an opening therethrough for the passage of light from the light source through the opening to the specimen from which the light is scattered onto the photosensitive surface from the specimen.

Preferred embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, of which:

Figure 1 is a schematic diagram illustrating one preferred form of the invention;

Figure 2 is a schematic view of the circuitry used in connection with Figure 1;

Figure 3 is a side elevational view partly broken away of another form of the invention;

Figure 4 is a diagrammatic view in perspective of other embodiment of the invention;

Figure 5 is a schematic diagram of circuitry employed in connection with Figure 4;

Figure 6 is a side elevational view partly broken away of another form of the invention; and

Figure 7 is a combined schematic and side elevational diagrammatic view of another form of the invention.

The operation of the instrument is based upon relative reflectivity, namely on a known value of reflectivity of many types of specimens. Based on this knowledge of reflectivity, the invention utilizes the relative optical power incident to a first photosensitive surface from a light source and that reflected onto a second photosensitive surface from the specimen. While the instrument can be employed for a variety of uses, typical applications include but are not limited to the surfaces of metals.

In its preferred form, the invention eliminates the need for many lenses, reduces complexity and alignment requirements but still provides accurate surface reflectance information. Thus it makes possible a cost effective alternative to presently available surface reflectance instruments.

The present invention is based upon the concept that a light source whether or not focused or columnated is picked up by two photosensors, one exposed directly to the light from the source and the other exposed indirectly after being reflected from the test specimen. In one preferred form of the invention, the specimen is illuminated through holes present in the center of the photosensors. If the beam of light is relatively narrow, all or virtually all of the light reflected from the specimen under test will be scattered back onto the photosensor this photonic energy scattered onto the photosensor is representative of the surface reflectance of the specimen under test. If it is known that a certain specimen when subjected to a particular industrial process that yields a certain quantity of surface reflectance, and if the specimen will be illuminated with a known light source which is positioned at a known angular relationship to the specimen, the specimen will reflect a quantity of light X. This quantity of light X, which is optical power is a reference figure for calibrating the instrument. Accordingly, from two signals, a) one derived from from a reference photosensor and b) a second from a photosensor that receives scattered light from the specimen positioned at a known relationship to the light source, the relative surface reflectance is determined.

Refer now to Figure 1. Illumination is provided by a light source 1 such as an LED, laser diode or any other convenient source of light. The particular type of light source should be compatible with the specimen 17 under study as will be apparent to those skilled in the art. The light source 1 is connected by means of conductors 2 to any suitable power source that is included in signal conditioning circuit 5. Between the light source 1 and the specimen 17 is a pair of photosensors 9 and 23 mounted back-to-back with photosensitive surfaces 11 and 24 respectively facing in opposite directions, the photosensitive surface 11 facing the source of light 1 and thephotosensitive surface 24

facing the specimen. A light apperture 13 which is common to photosensors 9 and 23, in this case substantially at the center, is aligned axially with the light source 1. The light source 1 thus projects a light beam depicted by envelope 7 illuminating the photosensitive surface 11 of the photosensor 9 over a defined area 8. The photosensor 9 intercepts the light envelope and serves as a reference photosensor. The reference photosensor 9 is connected to signal conditioning hardware 5 by means of conductors 19 and 27. The light aperture 13 at the center of the reference photosensor 9 and photosensor 23 allows the transmission of light within a smaller envelope 15 to pass through both photosensors to the surface of the specimen 17 under test. The light from the envelope 15 is scattered from the surface of specimen 17 under test onto the photosensitive surface 24 of the photosensor 23. Photosensor 23 is connected to the signal conditioning circuit 5 by means of conductors 29 and 27, the latter being common ground. Thorough the use of suitable signal conditioning circuits depicted in Figure 2, the information concerning the surface reflectance of the specimen 17 under test is derived. It will be noticed that photosensors 9 and 23 are held in close physical contact with one another and hence are always at the same temperature to assure accuracy and reproducibility of results.

Refer now to Figure 2 that describes details of signal conditioning hardware 5 of Figure 1. In the apparatus and method shown in Figure 2, the surface reflectance of the specimen 17 is compared to a standard (not shown) having a known surface reflectance producing a specific scatter characteristic when illuminated with the light source 1 located in the same relationship to the surface of the standard as it would be located in the relationship to the specimen 17. The derivation of the comparative measurement method will now be described. For the sake of description, it will be assumed that photosensors 9 and 23 are silicon photodiodes and that they are sensitive to the optical power projected from the light source 1 in Figure 1. While any suitable pair of photosensors can be employed, the guiding rule for choosing photodiodes made of a particular material and constructed in a special manner as known to the skilled in the art, is mainly its responsivity to the light source 1 (Figure 1). The photodiodes are in a heat conductive relationship but are insulated from one another electrically by means of at least insulating layer simply shown by numeral 25 (Figure 1). The photosensor 23 which intercepts scattered optical power from surface 17 is connected to an amplifier 31 by means of conductors 29 and 27. Across amplifier 31 there is a gain setting network 35, that may include filter (not shown), the purpose of which is to remove AC signals, if any, produced by ambient illumination such as 60 Hz for example. Any suitable amplifier with more detailed connections apparent to those skilled in the art can be used if desired. The signal output line 43 of the amplifier 31 will thus be a function of the photonic energy scattered from the surface of specimen 17 (Figure 1) or a reference surface, and the optical power projected through aperture 13, depending whether the instrument is being used in calibration or measurement mode, onto photosensor 23. The gain of amplifier 33 is programmable by means of altering the feedback network 37 through the signal line 39. The purpose for controlling the gain by adjusting the impedance of network 37 through programming signal 39 is to duplicate the scatter characteristic derived from a reference surface illuminated by the same instrument positioned in a known geometrical relationship to the reference surface. Therefore, when the instrument is being calibrated, a reference surface illuminated by the light source 1, will reflect scattered light onto photosensor 23 causing a corresponding signal 43. At this point in time, the operation (not shown), which can be a person or a device programmed to perform calibration will produce a signal via line 39 to equalize the output 41 which is being derived from the optical power intercepted by the reference photosensor 9. signals 41 and 43 are connected to a comparing circuit such as a ratio circuit 45. The signal 43 is a numerator and the signal 41 is the denominator of the ratio. The output of the ratio circuit 45 which devides signal 43 by signal 41 is depicted by numeral 47 can be in a digital or analog form. Once signals 43 and 41 are equalized as a part of calibration procedure, the output 47 will be equivalent to 1. It can be seen therefore that the output 47 will be largely independent of the optical power produced by the light source 1 (Figure 1). The calibration now is complete. The instrument can be used to test specimen 17 which was made of the same material and processed by the same process as the reference surface. During use, the instrument will be positioned in the same manner in reference to the specimen 17 as it was positioned in toward the reference surface. Signal changes in the output line 47 will indicate whether the surface reflectance of specimen 17 is higher or lower than that of the reference surface. For example, if the surface reflectance of specimen 17 is higher than the surface reflectance of the reference surface, then the output 47 will be lower than 1. An appropriate scale can be used to quantify the deviations of surface reflectance from 1. The signal 47 can be connected to a display 49 or other audible or visible indicator providing the user with alarms or information indicative of acceptable surface reflectance conditions based on operators criteria. In this regard one can

also say that the ratio signal 47 is largely independent of the variations of the optical power produced by light source 1. This is true since signals 43 and 41 are also proportianal to the optical power projected by the light source 1. This type of an operation of calibration and test can be performed for many types of materials subjected to many types of processes. The programming signal 39 can be tabulated and recorded by the operator for ease of instrument application. Accordingly, accurate readings corresponding to surface reflectance are provided.

Refer now to Figure 3, which illustrates another form of the instrument embodying the invention with the same numerals indicating parts described above. The instrument indicated generally by numeral 53 comprises an upright cylindrical barrel or tube 54 within which the light sources 1 is mounted near the top. the photosensors 9 and 23 with central aperture 13 are mounted near the lower end of the barrel which has an opening 14 at its lower end above the surface of the specimen 17. The barrel 54 is supported upon a bracket 56 secured thereto by means of screw 56a. Bracket 56 is attached to an arm 59 which is threaded to accomodate bracket 56. The arm 59 is secured by means of a hand wheel 56b to the stand 58 having a post 58a to provide a supporting fixture. Therefore by hand wheel 56b one can change the vertical position of the barrel 54, and by bracket 56 one can change the angular position of the barrel as relates to the surface of the specimen, or a reference surface. In this way the instrument 53 having an optical axis 53a can be used in desirable and controllable orientation toward the specimen 17, and at a controllable distance d between the surface 17 and photosensor 23. Depending on the optical power distribution from the light source 1, one may add a lens 50b that will help to couple more light through the aperture 13 to surface 17. The connections of photosensor 9 and 23 to the general signal conditioning hardware 5 (Figure 1) are provided via cable 67. For clarity of illustration, the conductors 19, 27 and 29 within cable 67 and photosensors 9 and 23 are not shown in the barrel 54. Therefore, such a fixture can be used to calibrate and use the instrument described in Figures 1 and 2.

Refer now to Figure 4 which illustrates a modified form of the invention and wherein the same numerals refer to corresponding parts already described. Light is provided by light source 1 powered by drive circuit 3 which is connected to the light source via conductor 2. Instead of using a single photodiode for photosensor 9 and a single photodiode for photosensor 23 as was illustrated in Figure 1, each of the photosensors 9 and 23 is made out of four photodiode segments that are electrically insulated from each other arranged around the optical axis 78 of the instrument in a four quadrant arrangement. They have a central and common aperture 13 essentially in the center of the intersection lines 72 and 73 of the quadrants of photosensor 9. Lines 74 and 75 separaring photosensor 23 into four elictrically isolated photodiodes distributed around aperture 13 are partially obstructed from view in this figure. Lines 74 and 75 may not coincide with extended lines 72 and 73. As in Figure 1 the light source 1 is mounted in such way that it projects a light within envelope 7 along an axis or symmetry line 78 perpendicular to the photosensor 9. As illustrated in Figure 5, photosensor 9 is connected via four lines 76a, 76b, 76c and 76d that correspond to photodiodes 9a, 9b, 9c and 9d within photosensor 9, to signal conditioning hardware 79. Photosensor 23 is connected via four lines 77a, 77b, 77c and 77d that correspond to the four photodiodes 23a, 23b, 23c and 23d to signal conditioning hardware 79. Other connections to the signal conditioning hardware include a common ground line 27 and lines 2 to supply current to light source 1. The construction and operation of the invention as shown in Figure 4 will now be described with reference to the signal conditioning hardware 79, that is shown in Figure 5.

As shown in Figure 5, the photosensors 9 and 23 are separated for illustration purposes only. Signals 76a, 76b, 76c, 76d, 77a, 77b, 77c and 77d are fed into an amplifier circuit 81 that amplifies the signals produced by the photodiodes of photosensors 9 and 23. As known to the skilled in the art the amplification can be performed by a single amplifier by means of sequencing the corresponding signals for amplifications. However, for the ease and clarity of explanation, the circuit 81 contains eight amplifiers producing amplified signals 83a, 83b, 83c and 83d , proportianal to the optical power intercepted by photodiodes 9a, 9b, 9c and 9d, and 85a, 85b, 85c and 85 d, proportional to the optical power intercepted by photodiodes 23a, 23b, 23c and 23d. Signals 83a, 83b, 83c and 83d are fed into circuit 87 producing two outputs 89 and 91. The output 89 corresponds to the relationship produced by the sum of signals 83b and 83d, minus the sum of the signals 83a and 83c. This relationship of amplified optical power intercepted by photosensor 9 is one measure of the light source 1 alignment with the axis of the aperure 13. Signal 91 corresponds to the sum of signals 83a, 83b, 83c and 83d. Means for implementation of such summing functions are known to those skilled in the art.

Signals 89 and 91 are fed into circuit 93 which can switch different inputs based on commands from an operator or from a programmable circuit 95. The control of the programmable circuit 95 is

indicated by signal line 97. Therefore, the signal line 97 will allow the circuit 93 to produc two outputs 99 and 101 which will correspond to these signals 89 and 91, or 103 and 105, or 107 and 109. Signals 99 and 101 which according to the sequence of operations performed by the instrument will represent signals 89 and 91, are connected to a devider circuit that produces a ratio between signals 89 and 91. This ratio signal 113 will correspond to the angular orientation, i.e., the degree of alignment between light source 1, aperture 13 and photosensors 9 and 23. The ratio signal is fed to the operator or a programmable device 95.

A correction to the alignment of the light source 1 to aperture 13 can be implemented mechanically, or mathematically by the operator or the programmable circuit 95. At the particular part of the sequence in which signal 113 represents the ratio between signals 89 and 91, where 89 is the numerator and 91 is the denominator, the signal 113 is largely independent of the optical power produced by the light source 1. Signals 85a, 85b, 85c and 85d which represent optical power scattered from surface 17, or reference surface (not shown in the figure), are connected to the signal conditioning circuit 115 which, like circuit 87 produces two output signals. The signal 103 corresponds to the sum of signals 85b and 85d minus the sum of the signals 85a and 85c. Signal 105 represents the sum of signals 85a, 85b, 85c and 85d. Signals 103 and 105 are connected to circuit 93 which in the proper sequence of steps to operate the instrument, will feed these signals on lines 99 and 101 correspondingly to the ratio circuit 111, which is in turn connected to a programmable circuit or operator simply labled 95. This ratio is largely independent of variations of optical power projected by the light source, and it will indicate the alignment angle between the instrument and the surface 17 or the reference surface. If the photosensor 9 and 23, the aperture 13 and the light source are perfectly aligned along the symetry axis, the signals 83a, 83b, 83c and 83d will be essentially equal to each other, otherwise the ratio between signal 89 and signal 91 will represent a reference alignment error. This means that if a surface were illuminated perpendicularly through the aperture 13, the axis of the instrument will be tilted by the alignment error, which in turn will affect the scatter characteristic of optical power reflected from the surface 17 or a reference surface. Therefore it will be also necessary to correct for the reflected scatter characteristic as intercepted by photosensor 23. This is done by providing a mathematical correction with the programmable circuit 95 or other mechanical means.

Based on the signals 83a, 83b, 83c and 83d, circuit 87 also produces an output 107 that is proportional to the average power intercepted by th reference photosensor 9. Based on signals 85a, 85b, 85c and 85d, circuit 115 produces signal 117 which is proportional to the average optical power intercepted by photosensor 23. Signal 117 is fed to circuit 119 which provides alignment corrections if needed from programmable circuit 95. The correction signal 121 is based on the angular alignment between photosensor 23 and the surface of specimen 17 or a reference surface, and the alignment error, if any, between light source 1 and photosensor 9. The output of circuit 119 is signal 109. Signals 109 and 107 are fed via a switching network 93 and the ratio circuit 111 to the programmable circuit 95. The resultant ratio of the signals 109 and 107 will represent the surface reflectance of specimen 17. This ratio will be largely independent of variations of optical power projected from the light source 1. At first, one will use the reference surface at a known geometrical oreientation to the instrument. The instrument is calibrated by storing the different alignment characteristics described above by the programmable circuit 95 which will equalize output signal 107 to the signal 109 (e.g., by use of memory in the programmable circuit 95 and signal 121). Thus the resultant ratio between signals 107 and 109 will be 1. If one will exchange the reference surface with with specimen 17 which was made of the same material and in the same manner as the reference, the ratio of the signal 109 over 107 will indicate reflectance characteristic.

Refer now to Figure 6 which illustrates instrument 53 which may be a hand-held instrument in accordance with the present invention generally similar in shape and size to a fountain pen. The same numerals refer to corresponding parts already described. Conductors 2, 76, 27 and 77 pass through a cord 67. In this case the instrument 53 consists of a hollow barrel 54 having an upper end 50 supporting the light source 1. As already described the light from the light source falls onto the reference photosensor 9 within cone depicted by envelope 7. The barrel 54 of the instrument 53 is provided with an opening at its lower end surrounded by a supporting rim 50a which rests during operation on the test specimen 17. The supporting rim 50a as shown is oriented at right angles to the axis of the barrel 54 thereby orienting the axis of the light envelope 7 perpendicular to the surface of the specimen 17.

The instrument is held manually in contact with th surface 17. The supporting rim 50a can be composed of some substance such as Teflon or other material that will not contaminate or the surface 17. The internal wall 61 within the instrument below the photosensor 23 is preferably coated with nonreflective coating that will prevent higher order

defractions of scattered light onto photosensor 23. the instrument 53 establishes three distanc s: the distance between a) the light source 1 and the first photosensor 9, b) between the light source 1 and the specimen 17 and c) between the speciment 17 and the second photosensor 23. These distances are established by structural parts of the apparatus including the barrel 54 supporting the light source 1 and photosensors 9 and 23, and the supporting rim 50a. The instrument 53 can be tilted back and forth as indicated by broken line 51 to seat the supporting rim 50a on the specimen 17.

Using the hend-held instrument, one can perform a calibration or an alignment operation at a certain angular relationship to the reference or the test surface 17. The operator can tilt the instrument 53 randomly, while the programmable circuit 95 will monitor signals 103 and 105. When signals 103 and 105 will satisfy the predetermined alignment conditions, signals 109 and 107 will be fed to the programmable circuit 95. Moreover, using the hand-held instrument one can perform a calibration sequence of operations by means of commanding the programmable circuit 95 in Figure 5 to take data only at a ceratain orientation between the instrument 53 and the reference surface. In this case, instrument 53 will be programmed to accept signals 103 and 105 only under the same orientation conditions between surface 17 as they were obtained in relationship to the reference surface.

Refer now to Figure 7 which illustrates another form of the invention. In the instrument in Figure 7, the light source 1 is mounted at the end of optical fiber(s) at the top end 62. The fiber(s) are devided into two parts, 64 and 66, which are brought into proximity with the photosensor 23 and the photosensor 9 respectively. Preferrably, the fiber(s) 66 are secured to the aperture 13 with a suitable adhesive. It will be noticed that the photosensor 23 and the photosensor 9 are located close together in a heat conductive relationship reducing the possibility of a temperature gradient between them. The same is true and evident from the description provided for photosensor 9and 23 in Figures 1 and 4 in which it will be noticed that they are held in physical contact with one another and hence are always at the same temperature to assure accuracy and reproducibility of results. The light reflected from the specimen 17 under test will be intercepted by the photosensor 23. The signal conditioning hardware of Figures 2 and 5 can be used dependent on whether or not photosensor 23 is a four quadrant photosensor.

Besides the simplicity and accuracy, the instrument in accordance with the present invention has other advantages. There is no need for special lenses or precision ground mirrors. There is no need for a precision voltage or current reference, and the light source need not b very stable.

Moreover, the present invention provides most of the advantages of prior equipment and overcomes shortcomings thereof through a unique method of transmitting and receiving optical power. It therefore reduces the complexity of the signal processing needed to provide final results in describing surface reflectance.

The invention also provdes an opportunity to use a relatively small numerical aperture that easily separates specular and diffused reflectances, and by this means reduces the need for Coblentz spheres previously used in commercially available total integrated scatter instruments while the instrument of the present invention uses aperture, its principle of operation is substantially different from the typical total integrated scatter instrument of the prior art which in operation is directly dependent on the relationship between the wavelength of the light source and the surface reflectance.

Claims

1.An instrument for measuring reflectance of a specimen characterised in that it comprises a light source, a first photosensitive surface in an optical relationship with the light source to receive impinging rays from the said light source, a second photosensitive surface positioned relative to the light source and positionable with respect to a specimen to receive rays reflected from the specimen, supporting means to establish the distance between, a) the light source and the first photosensitive surface, b) the light source to the specimen, and c) the specimen to the second surface, circuit means connected to the photosensitive surfaces for comparing the signal from the first and second photosensitive surfaces and output means connected to the comparing means indicating the reflectance of the specimen, at least one of the photosensitive surfaces having an opening therethrough for the passage of light from the light source through the opening to the specimen from which the light is scattered onto the photosensitive surface from the specimen.

2. An instrument according to claim 1 wherein the photosensitive surfaces are supported in a back-to-back relationship with a passage in the instrument allowing at least a portion of the rays from the light source to pass both photosensitive surfaces without impingement thereupon and thereafter strike the specimen.

3. An instrument according to claim 1 wherein the first and the second photosensitive surfaces are positioned adjacent to one another in a back-to-back relationship to form a sandwich structure and said first and second photosensitive surfaces com-

prise photosensitive elements divid d into photosensitive segments distributed radially about an optical axis passing from the light source to the photosensitive suerfaces, a first conductor means connecting each of the segments of the first photosensitive surface to a first signal comparing circuit, a second conductor means connecting each of the segments of the second photosensitive surface to a second signal comparing circuit, whereby through comparing the signal received from the segments of the photosensitive surfaces, differences in the amount of light received by each segment can be detected and the detected differences in the signal strengths received by the signal comparing circuits is connected to an indicator means to notify the user of the axial orientation of the instrument with respect to the specimen.

4. An instrument according to claim 1 wherein said photosensitive surfaces comprise a pair of photodiodes mounted in back-to-back relationship and ain a heat conductive relationship to maintain them at substantially the same temperature to thereby improve the accuracy and reproducibility of the readings taken and said photodiodes having aligned openings extending therethrough allowing a passage of light through the openings to the specimen whereby an envelope of rays from the light source will strike the first photodiode directly and the second photodiode after being scattered from the specimen and the signal comparing means comprises a divider circuit wherein the signal from one photodiode is a numerator signal and the signal from the second photodiode is a denominator signal, said divider circuit thereby providing a resultant ratio as a measure of relative surface reflectance which is largely independent of the optical power fluctuations.

5. An instrument according to claim 1 wherein the photosensitive surfaces are in a physical association with one another to be thereby in heat conductive relationship with one another to maintain both photosensitive surfaces at the same temperature to thereby assure accuracy and reproducibility of surface reflectance readings.

6. An instrument for measuring the surface reflectance of a specimen characterised in that it comprises first and second photosensitive surfaces, the first of which receives light directly from a light source such that light strikes the first photosensitive surface without reflection from another surface and the second of which receives light directly from a test specimen such that the scattered light strikes the second photosensitive surface without reflection from another surface, conductors connected to the photosensitive surfaces to carry signals therefrom proportional to the optical power of the incident light thereon and a comparing circuit means coupled to the conductors for comparing the output signals and indicator means connected to the circuit to provide an output signal designating reflectance of the specimen.

7. An instrument according to claim 6 wher in the instrument is calibrated by measuring light scattered from a standard specimen of known composition and surface quality to provide a known reflectance and said circuit means include gain control means for selectively changing the magnitude of said output signal to correspond to the known surface reflectance of the test specimen to thereby calibrate the instrument.

8. An instrument according to claim 6 or 7 wherein at least one of said photosensitive surfaces is divided into a plurality of coplanar electrically isolated photosensor segments arranged around an optical axis of a said instrument and circuit means is connected thereto for comparing an output signal of each segment to thereby derive the angular orientation of the coplanar segments to light incident thereto.

9. An instrument according to any of claims 6 to 8 wherein the second photosensitive surface has an aperture therein to admit light to the specimen from the light source.

10. An instrument according to any of claims 6 to 9 wherein the signal comparing means comprises a divider circuit adapted to establish a ratio between the signals from the first and second photosensors and the resulting ratio is largely independent of the optical power variations of the light source.

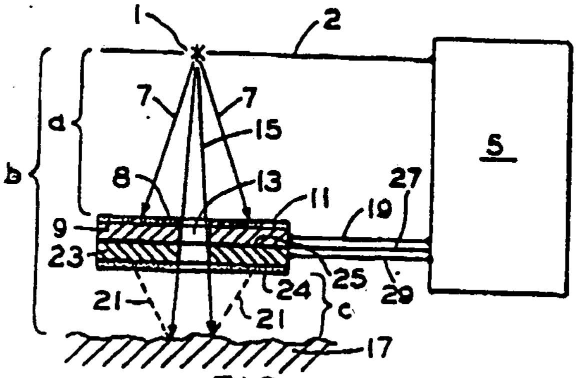

FIG. 1

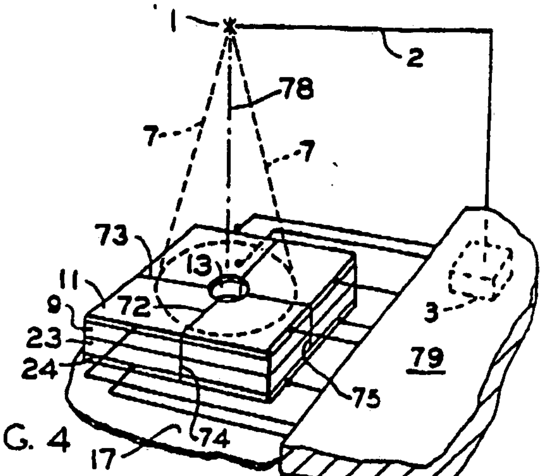

FIG. 4

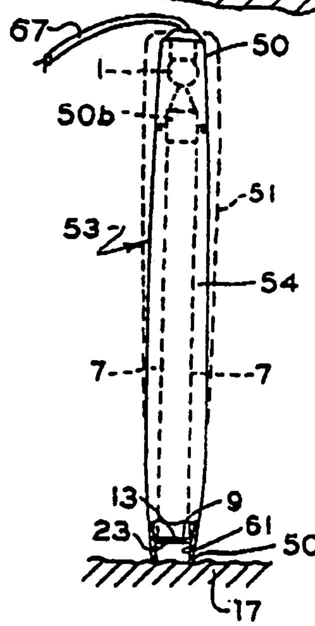

FIG. 6

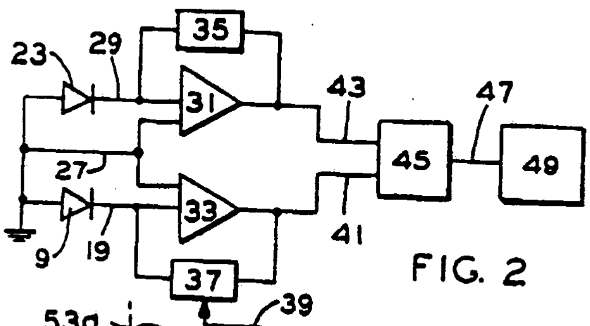

FIG. 2

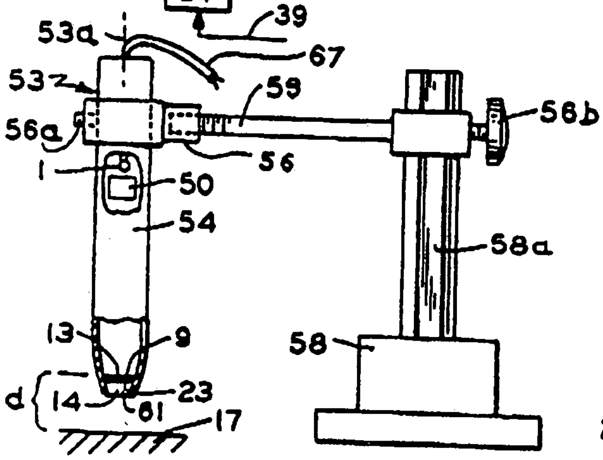

FIG. 3

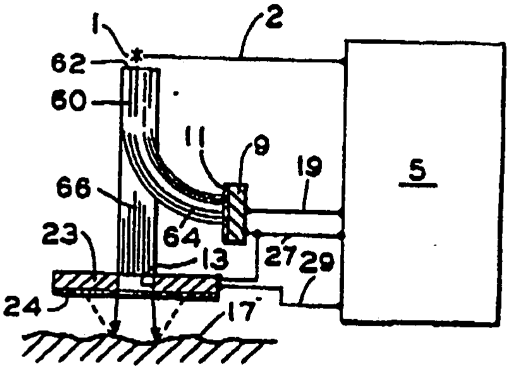

FIG. 7

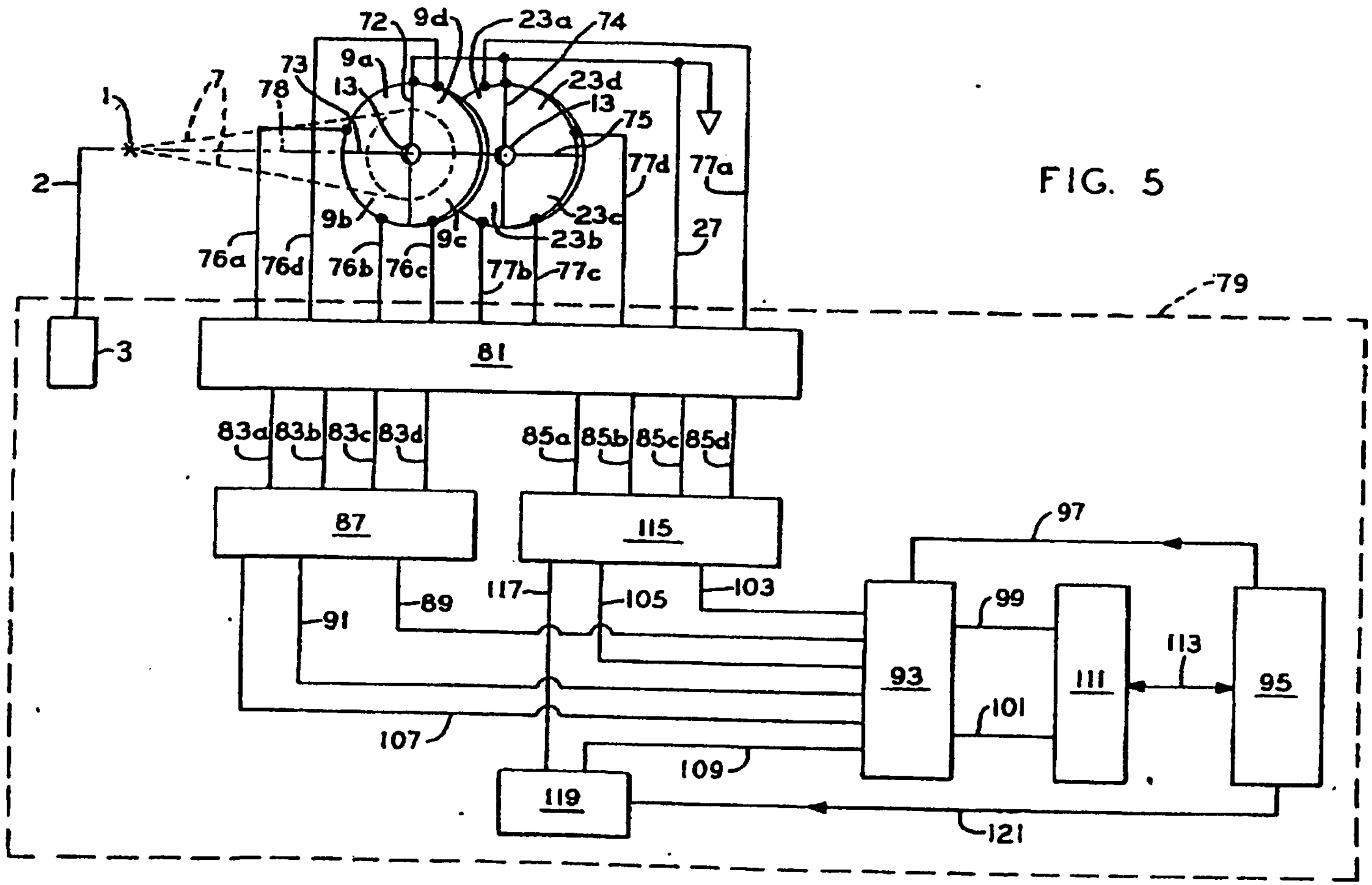

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FIG. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 88 30 8419

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	DE-A-1 937 503 (SIEMENS AG) * Whole document * ---	1-3	G 01 N 21/47 G 01 B 11/30
A	DE-A-2 553 536 (LANGE) * Pages 4,5; figure 1 * ---	1,6	
A	FR-A-2 131 055 (ETABLISSEMENTS JAY) * Page 1; figures 1,2 * ---	1,6	
A	FR-A-2 491 615 (T. GAST et al.) * Pages 7-11; figures 1,2 * ---	1,6	
A	PATENT ABSTRACTS OF JAPAN, vol. 12, no. 95 (P-681)[2942], 29th March 1988; & JP-A-62 228 143 (AGENCY OF IND. SCIENCE & TECHNOL.) 07-10-1987 * Abstract * ---	1	
A	PATENT ABSTRACTS OF JAPAN, vol. 12, no. 79 (P-676)[2926], 12th March 1988; & JP-A-62 217 144 (FUJI PHOTO FILM CO. LTD) 24-09-1987 * Abstract * ---	1,6	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
A	EP-A-0 154 875 (BOEHRINGER MANNHEIM) * Pages 11-13; figures 1,3 * -----	1,6	G 01 N 21/47 G 01 B 11/30 G 01 N 21/55

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	10-05-1989	BOEHM CH.E.D.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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PATENT ABSTRACTS OF JAPAN, vol. 12, no. 95 (P-681)[2942], 29th March 1988; & JP-A-62 228 143

PATENT ABSTRACTS OF JAPAN, vol. 12, no. 79 (P-676)[2926], 12th March 1988; & JP-A-62 217 144

(73) Proprietor: Golberstein, Moshe
2100 Drew Avenue South
Minneapolis Minnesota 55416(US)

(72) Inventor: Golberstein, Moshe
2100 Drew Avenue South
Minneapolis Minnesota 55416(US)

(74) Representative: Powell, Stephen David et al
WILLIAMS, POWELL & ASSOCIATES 34
Tavistock Street
London WC2E 7PB(GB)

Description

Of the many instruments proposed for measuring surface reflectance optically, none are completely satisfactory with respect to cost, size, portability and accuracy. Most, if not all, prior instruments require an optical system that includes many lenses and other costly components such as half-silvered mirrors and special alignment schemes which increase cost, size, bulk and reduce portability.

DE-OS-1 937 503 (SIEMENS AG) discloses an instrument for measuring reflectance of a specimen comprising a light source, a first photosensitive surface in an optical relationship with the light source to receive impinging rays from the said light source, a second photosensitive surface positioned relative to the light source and positionable with respect to a specimen to receive rays reflected from the specimen, supporting means to establish the distance between, a) the light source and the first photosensitive surface, b) the light source and the specimen, and c) the specimen and the second photosensitive surface, and circuit means connected to receive photosensitive surface output signals, the first and the second photosensitive surfaces being positioned adjacent to one another in a back-to-back relationship to form a sandwich structure and the sandwich structure having a passage therethrough allowing a portion of the rays from the light source to pass both photosensitive surfaces without impingement thereupon and thereafter strike the specimen.

This disclosure corresponds to the introductory part of claim 1.

According to the present invention there is provided an instrument for measuring reflectance of a specimen comprising a light source, a first photosensitive surface in an optical relationship with the light source to receive impinging rays from the said light source, a second photosensitive surface positioned relative to the light source and positionable with respect to a specimen to receive rays reflected from the specimen, supporting means to establish the distance between, a) the light source and the first photosensitive surface, b) the light source and the specimen, and c) the specimen and the second photosensitive surface, and circuit means connected to receive photosensitive surface output signals, the first and the second photosensitive surfaces being positioned adjacent to one another in a back-to-back relationship to form a sandwich structure and the sandwich structure having a passage therethrough allowing a portion of the rays from the light source to pass both photosensitive surfaces without impingement thereupon and thereafter strike the specimen, characterised in that each of the first and second photosensitive surfaces comprises a plurality of photosensitive elements distributed about the optical axis passing from the light source to the photosensitive surfaces, first conductor means connecting each of the elements of the first photosensitive surface to the circuit means and second conductor means connecting each of the elements of the second photosensitive surface to the circuit means, the circuit means determining, from the photosensitive element output signals, values representing the reflectance of the specimen and the axial orientation of the instrument with respect to the specimen.

Preferred embodiments of the present invention will now be described by way of example only, with reference to the accompanying drawings, of which:

Figure 1 is a diagrammatic view, in perspective, of a first embodiment of the invention;

Figure 2 is a schematic diagram of circuitry employed in connection with the embodiment shown in Figure 1; and

Figure 3 is a side elevational view, partly broken away, of another embodiment of the invention.

The operation of the instrument is based upon relative reflectivity, namely on a known value of reflectivity of many types of specimens. Based on this knowledge of reflectivity, the invention utilizes the relative optical power incident to a first photosensitive surface from a light source and that reflected onto a second photosensitive surface from the specimen. While the instrument can be employed for a variety of uses, typical applications include, but are not limited,to the surfaces of metals.

In its preferred form, the invention eliminates the need for many lenses, reduces complexity and alignment requirements but still provides accurate surface reflectance information. Thus, it makes possible a cost effective alternative to presently available surface reflectance instruments.

The present invention is based upon the concept that a light source whether or not focused or collimated is picked up by two photosensors, one exposed directly to the light from the source and the other exposed indirectly after being reflected from the test specimen. The specimen is illuminated through holes present in the center of the photosensors. If the beam of light is relatively narrow, all or virtually all of the light reflected from the specimen under test will be scattered back onto the photosensor, this photonic energy scattered onto the photosensor is representative of the surface reflectance of the specimen under test. If it is known that a certain specimen when subjected to a particular industrial process, yields a c rtain quantity of surface reflectance, and if the specimen is illuminated with a known light source which is posi-

tioned at a known angular relationship to the specimen, the specimen will reflect a quantity of light X. This quantity of light x, which is optical pow r, is a reference figure for calibrating the instrument. Accordingly, from two signals, a) one derived from a reference photosensor and b) a second from a photosensor that receives scattered light from the specimen positioned at a known relationship to the light source, the relative surface reflectance is determined.

Refer now to Figure 1, which illustrates the first embodiment of the invention. Light is provided by light source 1, such as an LED, laser diode or any other convenient source of light. The particular type of light source should be compatible with the specimen 17 under study as will be apparent to those skilled in the art. The light source 1 is connected by means of conductors 2 to any suitable power source that is included in signal conditioning circuit 79. Between the light source 1 and the specimen 17 is a pair of photosensors 9 and 23 mounted back-to-back with photosensitive surfaces 11 and 24 respectively facing the source of light 1 and the photosensitive surface 24 facing the specimen. Each photosensor is made out of four photodiode segments 9a-9d, 23a-23d that are arranged around the optical axis 78 of the instrument. A light aperture 13 which is common to photosensors 9 and 23, in this case substantially at the center, is aligned axially with the light source 1. The light source 1 thus projects a light beam depicted by envelope 7 illuminating the phototsensitive surface 11 of the photosensor 9 over a defined area. The photosensor 9 intercepts the light envelope and serves as a reference photosensor. The elements of the reference photosensor 9 are connected to signal conditioning hardware 79. Light aperture 13 at the center of the reference photosensor 9 and photosensor 23 allows the transmission of light within a smaller envelope to pass through both photosensors to the surface of the specimen 17 under test. The light from the envelope is scattered from the surface of specimen 17 under test onto the photosensitive surface 24 of the photosensor 23. The elements of photosensor 23 are connected to the signal conditioning circuit 79. Through the use of suitable signal conditioning circuits depicted in Figure 2, the information concerning the surface reflectance of the specimen 17 under test is derived. It will be noticed that photosensors 9 and 23 are held in close physical contact with one another and hence are always at the same temperature to assure accuracy and reproducibility of results.

Refer now to Figure 2 that describes details of signal conditioning hardware 79 of Figure 1. In the apparatus shown in Figure 2, the surface reflectance of the specimen 17 is compared to a reference surface (not shown) having a known surface reflectance producing a specific scatter characteristic when illuminated with th light source 1 located in the same relationship to the reference surface as it would be located in the relationship to the surface of the specimen 17. Each photosensor 9, 23 comprises four silicon photodiodes 9a-9d, 23a-23d that are sensitive to the optical power projected from the light source 1. The photodiodes are chosen for their responsivity to the light source 1. The photodiodes are in a heat conductive relationship but are insulated from one another electrically by means of at least one insulating layer. The photosensors 9 and 23 are shown separated for for illustration purposes only.

Signals 76a, 76b, 76c, 76d, 77a, 77b, 77c and 77d, are fed into an amplifier circuit 81 that amplifies the signals produced by the photodiodes comprising photosensors 9 and 23. The circuit 81 contains eight amplifiers producing amplified signals 83a-83d, 85a-85d. The magnitude of the amplified signals is a function of the photonic energy scattered from the surface of specimen 17 or the reference surface, and the optical power projected through aperture 13, depending whether the instrument is being used in calibration or measurement mode. Other connections to the signal conditioning hardware 79 include a common ground line 27 and lines 2 to supply current to light source 1.

Signals 83a, 83b, 83c and 83d are fed into circuit 87 producing two outputs 89 and 91. The output 89 corresponds to the relationship produced by the sum of signals 83b and 83d, minus the sum of the signals 83a and 83c. This relationship of amplified optical power intercepted by photosensor 9 in one measure of the light source 1 alignment with the axis of the aperture 13. Signal 91 corresponds to the sum of signals 83a, 83b, 83c, and 83d. Means for implementation of such summing functions are known to those skilled in the art.

Signals 89 and 91 are fed into circuit 93 which can switch different inputs based on commands from an operator or from a programmable circuit 95. The control of the programmable circuit 95 is indicated by signal line 97. Therefore, the signal line 97 will allow the circuit 93 to produce two outputs 99 and 101 which will correspond to these signals 89 and 91, or 103 and 105, or 107 and 109. Signals 99 and 101 which according to the sequence of operations performed by the instrument will represent signals 89 and 91, are connected to a divider circuit that produces a ratio between signals 89 and 91. This ratio signal 113 will correspond to the angular orientation, i.e., the degree of alignment between light source 1, aperture 13 and photosensors 9 and 23. The ratio signal is fed to the operator or a programmable device 95.

A correction to the alignment of the light

source 1 to aperture 13 can be implemented mechanically, or mathematically by the operator or the programmable circuit 95. At the particular part of the sequence in which signal 113 represents th ratio between signals 89 and 91, where 89 is th numerator and 91 is the denominator, the signal 113 is largely independent of the optical power produced by the light source 1. Signals 85a, 85b, 85c, and 85d which represent optical power scattered from surface 17, or reference surface (not shown in the figure), are connected to the signal conditioning circuit 115 which, like circuit 87 produces two output signals. The signal 103 corresponds to the sum of signals 85b and 85d minus the sum of the signals 85a and 85a. Signal 105 represents the sum of signals 85a, 85b, 85c, and 85d. Signals 103 and 105 are connected to a circuit 93 which in the proper sequence of steps to operate the instrument, will feed these signals on lines 99 and 101 correspondingly to the ration circuit 111 which is in turn connected to a programmable circuit or operator simply labelled 95. This ratio is largely independent of variations of optical power projected by the light source, and it will indicate the alignment angle between the instrument and the surface 17 or the reference surface. If the photosensor 9 and 23, the aperture 13 and the light source are perfectly aligned along the symmetry axis, the signals 83a, 83b, 83c and 83d will be essentially equal to each other, otherwise the ratio between signals 89 and signal 91 will represent a reference alignment error. This means that if a surface were illuminated perpendicularly through the aperture 13, the axis of the instrument will be tilted by the alignment error, which in turn will affect the scatter characteristic of optical power reflected from the surface 17 or a reference surface. Therefore it will be also necessary to correct for the reflected scatter characteristic as intercepted by photosensor 23. This is done by providing a mathematical correction with the programmable circuit 95 or other mechanical means.

Based on the signals 83a, 83b, 83c and 83d, circuit 87 also produces an output 107 that is proportional to the average power intercepted by the reference photosensor 9. Based on signals 85a, 85b, 85c and 85d, circuit 115 produces signal 117 which is proportional to the average optical power intercepted by photosensor 23. Signal 117 is fed to circuit 119 which provides alignment corrections if needed from programmable circuit 95. The correction signal 121 is based on the angular alignment between photosensor 23 and the surface of specimen 17 or the reference surface, and the alignment error, if any, between light source 1 and photosensor 9. The output of circuit 119 is signal 109. Signals 109 and 107 are fed via switching network 93 and the ratio circuit 111 to the programmable circuit 95. The resultant ratio of the signals 109 and 107 will represent the surfac reflectanc of specimen 17. This ratio will b largely independent of variations of optical power projected from the light source 1. At first, one will use the reference surface at a known geometrical orientation to the instrument. The instrument is calibrated by storing the different alignment characteristics described above by the programmable circuit 95 which will equalize output signal 107 to the signal 109 (e.g., by use of memory in the programmable circuit 95 and signal 121). Thus the resultant ratio between signals 107 and 109 will be unity. If one exchanges the reference surface with specimen 17 which was made of the same material and in the same manner as the reference, the ratio of the signal 109 over 107 will indicate the reflectance characteristic of the specimen.

A number of modifications can be made to the embodiment shown in Figures 1 and 2. The signal conditioning hardware 79 can be connected to a display or other audible or visible indicator providing the user with alarms or information indicative of acceptable surface reflectance conditions based on operator's criteria.

Refer now to Figure 3 which illustrates instrument 53 which may be a hand-held instrument in accordance with the present invention generally similar in shape and size to a fountain pen. The same numerals refer to corresponding parts already described. Conductors 2, 76, 27, and 77 pass through a cord 67. In this case the instrument 53 consists of a hollow barrel 54 having an upper end 50 supporting the light source 1. As already described the light from the light source falls onto the reference photosensor 9 within cone depicted by envelope 7. The barrel 54 of the instrument 53 is provided with an opening at its lower end surrounded by a supporting rim 50a which rests during operation on the test specimen 17. The supporting rim 50a as shown is oriented at right angles to the axis of the barrel 54 thereby orienting the axis of the light envelope 7 perpendicular to the surface of the specimen 17.

The instrument is held manually in contact with the surface 17. The supporting rim 50a can be composed of some substance such as Teflon or other material that will not contaminate or the surface 17. The internal wall 61 within the instrument below the photosensor 23 is preferably coated with nonreflective coating that will prevent higher order defractions of scattered light onto photosensor 23. The instrument 53 establishes three distances: the distance between a) the light source 1 and the first photosensor 9, b) between the light source 1 and the specimen 17 and c) between the specimen 17 and the second photosensor 23. These distances are established by structural parts of the apparatus

including the barrel 54 supporting the light source 1 and photosensors 9 and 23, and the supporting rim 50a. The instrument 53 can be tilted back and forth as indicated by broken line 51 to seat the supporting rim 50a on the specimen 17.

Using the hand-held instrument one can perform a calibration or an alignment operation at a certain angular relationship to the reference or the test surface 17. The operator can tilt the instrument 53 randomly, while the programmable circuit 95 will monitor signals 103 and 105. When signals 103 and 105 will satisfy the predetermined alignment conditions, signals 109 and 107 will be fed to the programmable circuit 95. Moreover, using the hand-held instrument one can perform a calibration sequence of operations by means of commanding the programmable circuit 95 in Figure 2 to take data only at a certain orientation between the instrument 53 and the reference surface. In this case, instrument 53 will be programmed to accept signals 103 and 105 only under the same orientation conditions between surface 17 as they were obtained in relationship to the reference surface.

Besides the simplicity and accuracy, the instruments in accordance with the present invention have other advantages. There is no need for special lenses or precision ground mirrors. There is no need for a precision voltage or current reference, and the light source need not be very stable.

Moreover, the present invention provides most of the advantages of prior equipment and overcomes shortcomings thereof through a unique method of transmitting and receiving optical power. It therefore reduces the complexity of the signal processing needed to provide final results in describing surface reflectance.

The invention also provides an opportunity to use a relatively small numerical aperture that easily separates- specular and diffused reflectances, and by this means reduces the need for Coblentz spheres previously used in commercially available total integrated scatter instruments while the instrument of the present invention uses aperture, its principle of operation is substantially different from the typical total integrated scatter instrument of the prior art which in operation is directly dependent on the relationship between the wavelength of the light source and the surface reflectance.

Claims

1. An instrument for measuring reflectance of a specimen comprising a light source (1), a first photosensitive surface (11) in an optical relationship with the light source to receive impinging rays from the said light source, a second photosensitive surface (24) positioned relative to the light source and positionable with respect to a specimen (17) to receive rays reflected from the specim n, supporting means to establish the distance between, a) the light source and the first photos nsitive surface, b) the light source and th specimen, and c) the specimen and the second photosensitive surface, and circuit means (81-119) connected to receive photosensitive surface output signals, the first and the second photosensitive surfaces being positioned adjacent to one another in a back-to-back relationship to form a sandwich structure and the sandwich structure having a passage therethrough allowing a portion of the rays from the light source to pass both photosensitive surfaces without impingement thereupon and therafter strike the specimen, characterised in that each of the first and second photosensitive surfaces comprises a plurality of photosensitive elements distributed about the optical axis (78) passing from the light source to the photosensitive surfaces, first conductor means (76a-d, 83a-d)connecting each of the elements of the first photosensitive surface (11) to the circuit means and second conductor means (77a-d, 85a-d) connecting each of the elements of the second photosensitive surface to the circuit means, the circuit means determining, from the photosensitive element output signals, values representing the reflectance of the specimen and the axial orientation of the instrument with respect to the specimen.

2. An instrument according to Claim 1 wherein the first conductor means (76a-d, 83a-d) are connected to a first signal comparing circuit (87) and the second conductor means (77a-d, 85a-d) are connected to a second signal comparing circuit (115),the differences in the amount of light received by each element being detected, and the detected differences in the signal strengths received by the signal comparing circuits being supplied to means indicating the axial orientation of the instrument with respect to the specimen.

3. An instrument according to Claim 1 or 2, wherein said circuit means comprises a divider circuit (111), wherein a signal from one of the photosensitive surfaces is a numerator signal (109) and a signal from the other photosensitive surface is a denominator signal (107), said divider circuit thereby providing a resultant ratio representing the reflectance of the specimen.

4. An instrument according to any preceding claim wherein said photosensitive elements

comprise pairs of photodiodes mounted in back-to-back relationship and in a heat conductive relationship to maintain them at substantially the same temperature.

5. An instrument according to any preceding claim arranged to be calibrated by measuring light scattered from a standard specimen of known composition and surface quality to provide a known reflectance, wherein said circuit means (81-119) include gain control means (95) for selectively changing the magnitude of a reflectance-indicating signal to correspond to the known surface reflectance of the test specimen to thereby calibrate the instrument.

Revendications

1. Appareil pour mesurer la réflectance d'un échantillon comprenant une source lumineuse (1), une première surface photosensible (11) en relation optique avec la source lumineuse pour recevoir des rayons incidents venant de la source lumineuse, une seconde surface photosensible (24) disposée relativement à la source lumineuse et susceptible d'être disposée par rapport à un échantillon (17) pour recevoir des rayons réfléchis par l'échantillon, des moyens de support pour définir la distance entre : a) la source lumineuse et la première surface photosensible, b) la source lumineuse et l'échantillon et c) l'échantillon et la seconde surface photosensible, et des circuits (81-119) connectés pour recevoir les signaux de sortie des surfaces photosensibles, les première et seconde surfaces photosensibles étant positionnées côte à côte et dos à dos pour former une structure en sandwich et la structure en sandwich étant traversée par un passage qui laisse passer une partie des rayons venant de la source lumineuse vers les deux surfaces photosensibles sans frapper directement ces surfaces et frappant ensuite l'échantillon, caractérisé en ce que chacune des première et seconde surfaces photosensibles comprend un ensemble d'éléments photodétecteurs répartis autour de l'axe optique (78) allant de la source lumineuse aux surfaces photosensibles, des premiers conducteurs (76a-d, 83a-d) connectant chacun des éléments de la première surface photosensible (11) aux circuits et des seconds moyens conducteurs (77a-d, 85a-d) reliant chacun des éléments de la second surface photosensible aux circuits, les circuits déterminant, à partir des signaux de sortie des éléments photosensibles, des valeurs r présentant la réflectance de l'échantillon et l'orientation axiale de l'appareil par rapport à l'échantillon.

2. Appareil selon la revendication 1, dans lequel les premiers moyens conducteurs (76a-d, 83a-d) sont conn ctés à un premier circuit comparateur de signaux (87) et les seconds moyens conducteurs (77a-d, 85a-d) sont connectés à un second circuit comparateur de signaux (115), les différences de quantité de lumière reçue par chaque élément étant détectées et les différences détectées dans les intensités des signaux reçus par les circuits comparateurs de signaux étant appliquées à des moyens indiquant l'orientation axiale de l'appareil par rapport à l'échantillon.

3. Appareil selon la revendication 1 ou 2, dans lequel lesdits circuits comprennent un circuit diviseur (111), dans lequel un signal délivré par l'une des surfaces photosensibles est un signal numérateur (109) et un signal délivré par l'autre surface photosensible est un signal dénominateur (107), ledit circuit diviseur délivrant ainsi un rapport résultant représentant la réflectance de l'échantillon.

4. Appareil selon l'une quelconque des revendications précédentes dans lequel lesdits éléments photosensibles comprennent des paires de photodiodes montées dos à dos et en relation de conduction thermique pour les maintenir sensiblement à la même température.

5. Appareil selon l'une quelconque des revendications précédentes agencé pour être étalonné en mesurant la lumière diffusée par un échantillon standard de composition connue et de qualité de surface connue pour créer une réflectance connue, dans lequel lesdits circuits (81-119) comprennent des moyens de commande de gain (95) pour modifier sélectivement l'amplitude du signal indicatif de réflectance, afin qu'il corresponde à la réflectance de surface connue de l'échantillon de contrôle, en sorte d'étalonner ainsi l'appareil.

Patentansprüche

1. Ein Instrument zur Messung des Reflexionsgrades eines Prüflings, umfassend eine Lichtquelle (1), eine erste lichtempfindliche Oberfläche (11), die mit der Lichtquelle in optischer Beziehung steht, um auftreffende Strahlen der Lichtquelle zu empfangen, eine zweit lichtempfindliche Oberfläche (24), die relativ zu der Lichtquelle angeordnet ist und in Bezug auf einen Prüfling (17) einstellbar ist, um von dem Prüfling reflektierte Strahlen zu empfangen,

eine Stützvorrichtung zur Festlegung der Entfernung zwischen a) der Lichtquelle und der ersten lichtempfindlichen Oberfläche, b) der Lichtquelle und dem Prüfling und c) dem Prüfling und der zweiten lichtempfindlichen Oberfläche und ferner Schaltkreise (81-119), die so geschaltet sind, daß sie Ausgangssignale der lichtempfindlichen Oberflächen empfangen können, wobei die erste und die zweite lichtempfindliche Oberfläche nebeneinander, Rükken an Rücken in Sandwichaufbau angeordnet sind und in dem Sandwichaufbau ein Durchgang vorgesehen ist, der es ermöglicht, daß ein Teil der von der Lichtquelle ausgesandten Strahlen beide lichtempfindliche Oberflächen passiert, ohne auf sie aufzufallen und danach auf den Prüfling auftreffen, **dadurch gekennzeichnet**, daß sowohl die erste als auch die zweite lichtempfindliche Oberfläche eine Mehrzahl lichtempfindlicher Elemente umfaßt, die um die optische Achse (78), die von der Lichtquelle zu den lichtempfindlichen Oberflächen verläuft, verteilt sind, daß erste Leitungen (76a-d, 83a-d) jedes der Elemente der ersten lichtempfindlichen Oberfläche (11) mit den Schaltkreisen und daß zweite Leitungen (77a-d, 85a-d) jedes der Elemente der zweiten lichtempfindlichen Oberfläche mit den Schaltkreisen verbinden, wobei die Schaltkreise aus den Ausgangssignalen der lichtempfindlichen Elemente Werte liefern, die das Reflexionsvermögen des Prüflings und die axiale Ausrichtung des Instrumentes in Bezug auf den Prüfling repräsentieren.

2. Ein Instrument nach Anspruch 1, bei dem die ersten Leitungen (76a-d, 83a-d) mit einer ersten Signalvergleichsschaltung (87) und die zweiten Leitungen (77a-d, 85a-d) mit einer zweiten Signalvergleichsschaltung (115) verbunden sind, die Unterschiede der Lichtmenge, die von jedem Element empfangen wird, ermittelt werden und die ermittelten Unterschiede in den Signalstärken, die von den Signalvergleichsschaltungen empfangen werden, einer Vorrichtung zugeführt werden, die die axiale Ausrichtung des Instrumentes bezüglich des Prüflings anzeigt.

3. Ein Instrument nach Anspruch 1 oder 2, bei dem die Schaltkreise eine Dividierschaltung (111) umfassen, in der ein, von der einen der lichtempfindlichen Oberflächen kommendes Signal ein Zählersignal (109) und ein von der anderen lichtempfindlichen Oberfläche kommendes Signal ein Nennersignal (107) darstellt, und die Dividierschaltung einen sich daraus ergebenden Verhältniswert liefert, der dem Reflexionsv rmögen des Prüflings ntspricht.

4. Ein Instrument nach ein m der vorhergehenden Ansprüche, bei dem die lichtempfindlichen Elemente Fotodiodenpaar umfassen, die Rükken an Rücken und in wäremleitender Beziehung angeordnet sind, um sie auf im wesentlichen der gleichen Temperatur zu halten.

5. Ein Instrument nach einem der vorhergehenden Ansprüche, das angeordnet ist, um durch Messung von Licht geeicht zu werden, das von einem Standardprüfling bekannter Zusammensetzung und Oberflächeneigenschaft gestreut wird, um ein bekanntes Reflexionsvermögen zu liefern, bei dem die Schaltkreise (81 - 119) einen Verstärkungsregler (95) zur selektiven Änderung der Größe eines das Reflexionsvermögen anzeigenden Signals umfassen, damit dieses dem bekannten Oberflächenreflexionsvermögen des Testprüflings entspricht, um hierdurch das Instrument eichen zu können.

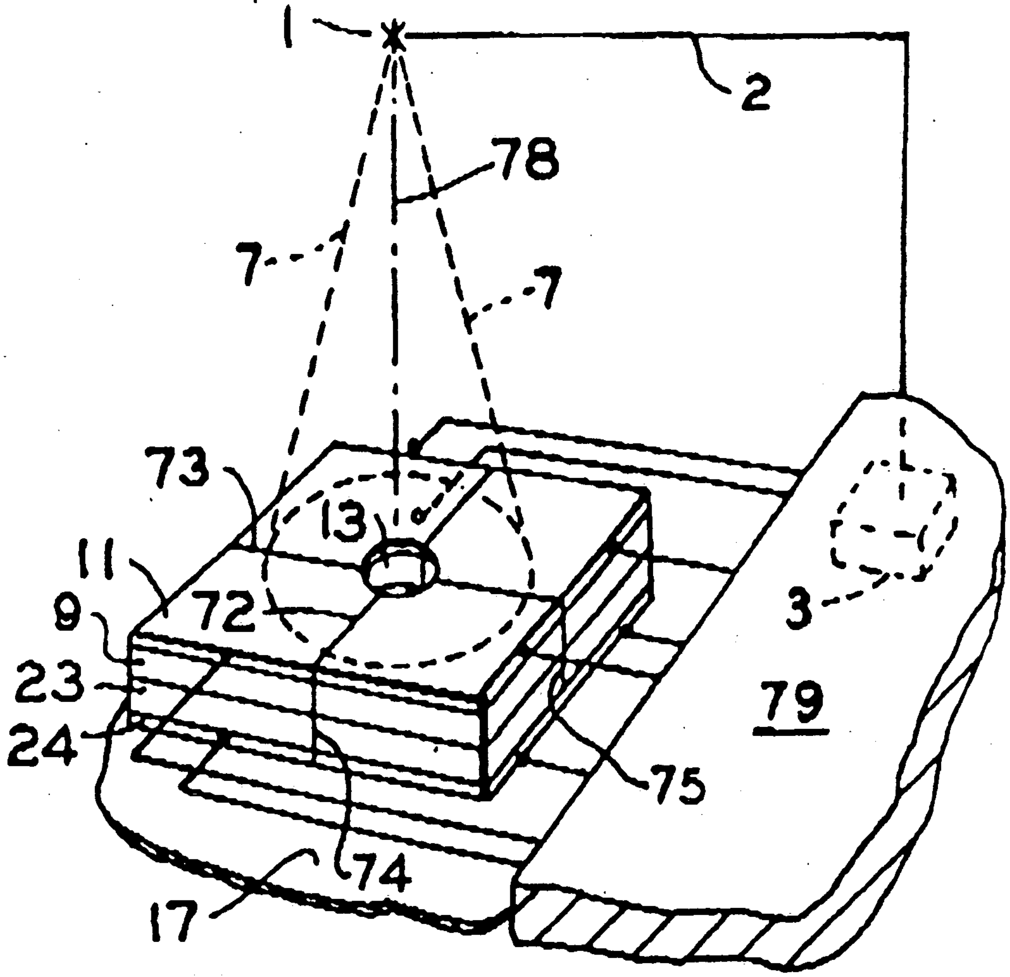
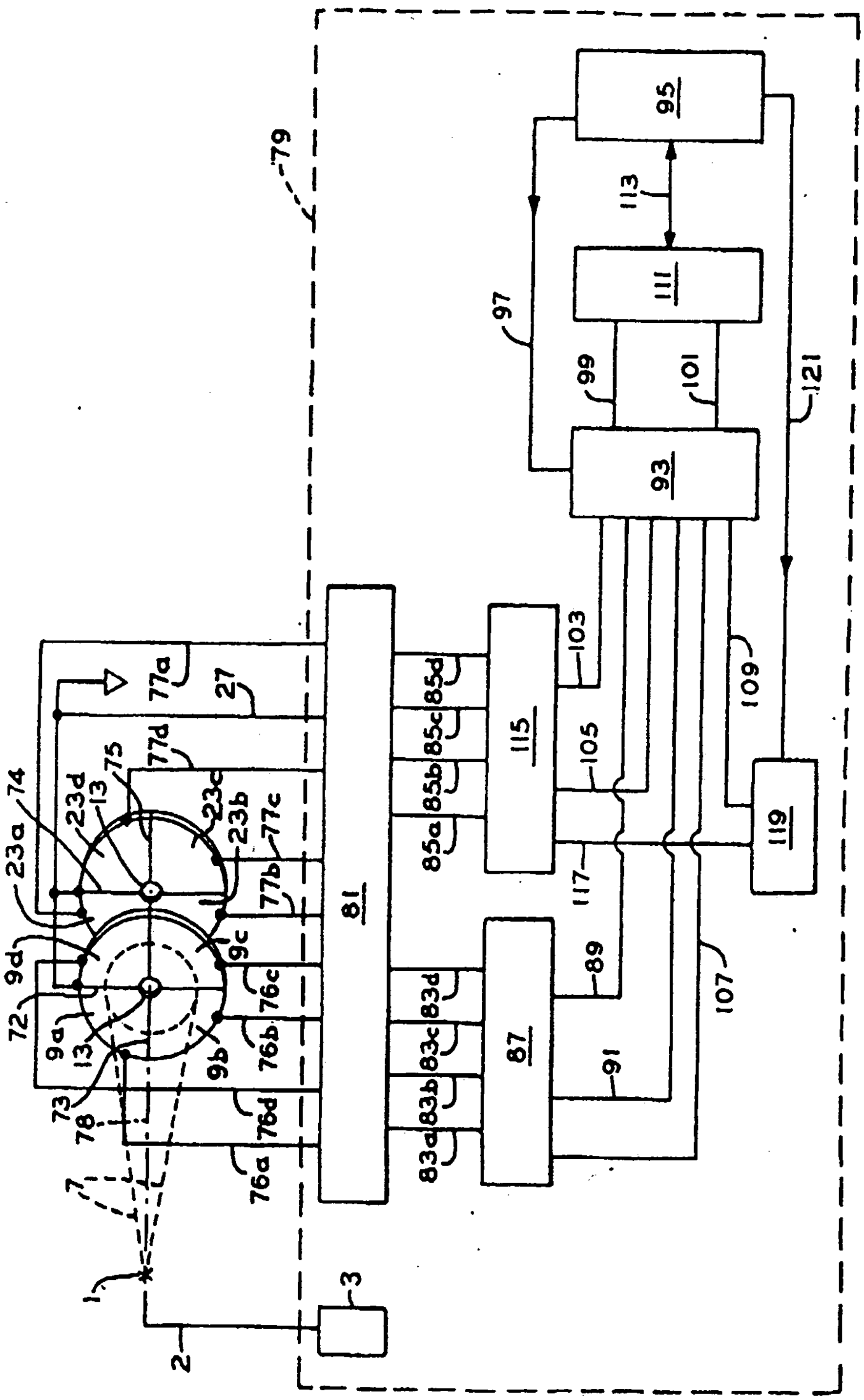


FIG. 1


79
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81
85a
85b
85c
85d
83a
83b
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83d
77a
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77b
76a
76b
76c
76d
74
75
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7
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2
3

FIG. 2

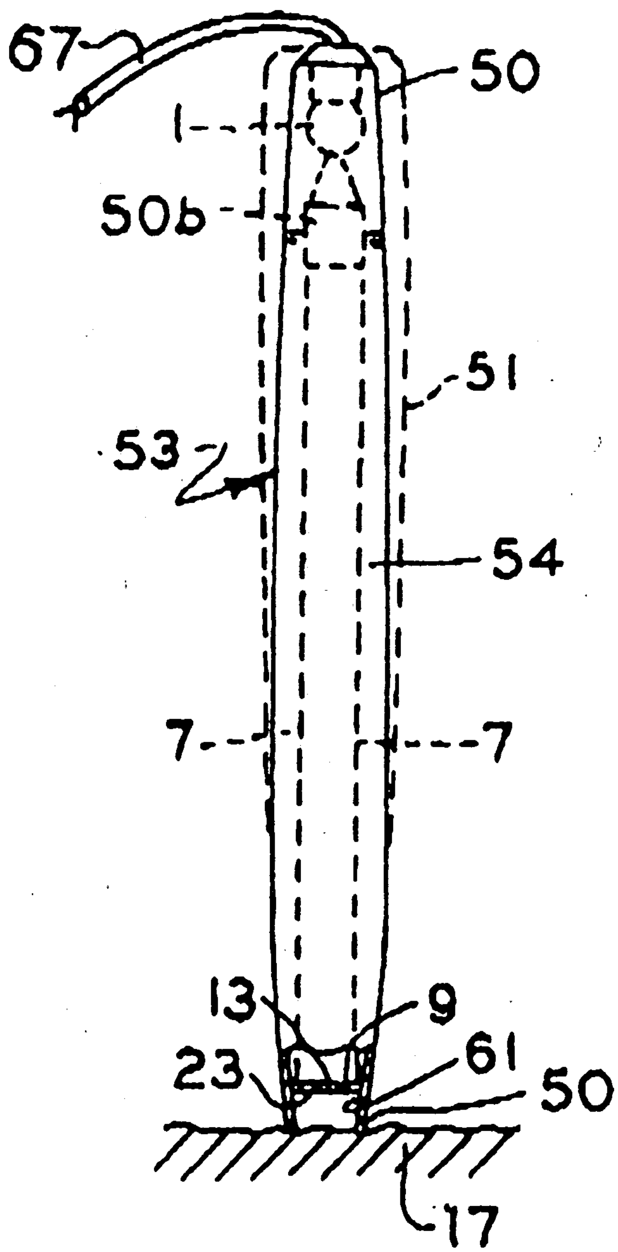

Fig. 3